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VEGETABLES—

Consumer Quality, Yield, and Preparation Time of Various Market Forms

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

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VEGETABLES—Consumer Quality, Yield, and Preparation Time of Various Market Forms

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SUMMARY

Preparation time requirements, yield, and quality of six frozen, fresh, and canned vegetables—green beans, lima beans, broccoli, brussels sprouts, green peas, and spinach—were determined. Preparation time and yield were also determined on five additional vegetables in various market forms—asparagus, corn, sweetpotatoes, beets, and carrots.

Of the frozen vegetables investigated, total preparation time ranged from 12 minutes for asparagus and whole kernel corn to 99½ minutes for corn on the cob. The within-sample weight variation of family-sized packages was not great. Widest ranges in net weight per package were found in green beans, broccoli, brussels sprouts, and spinach. Green peas and lima beans were least variable. Mean values for percentage yield of the vegetables when cooked and drained ranged from 77 percent for spinach to 101 percent for corn on the cob.

Mean ascorbic acid values for frozen vegetables ranged from 79 mg. per 100 g. for brussels sprouts to 9 mg. for green beans. Coefficients of variation for ascorbic acid content ranged from 12 to 13 percent except for green beans, 33 percent, and spinach, 37 percent. Mean values for ratios of oxidized to reduced ascorbic acid were highest for green beans, 0.54, and lowest for broccoli, 0.16. The low ratio of oxidized to reduced ascorbic acid for broccoli indicated good quality maintenance. Retention of reduced ascorbic acid in the cooked frozen vegetables was from 59 to 75 percent of that present in the uncooked.

There was considerable variation in percentage conversion of chlorophyll to pheophytin in the frozen vegetables investigated. Relatively high values are another measure of deterioration in quality. Vegetables purchased on the retail market in the summer season tended to be highest in chlorophyll conversion. The longer storage period and the difficulty in maintaining a storage temperature as low as 0° F. during the summer season may account for the higher chlorophyll conversion values of samples tested during this season.

Sample to sample variation in shear-force values indicated wide ranges in texture in the uncooked frozen vegetables, especially broccoli, range 680 to 2,230 pounds, and spinach, 172 to 1,170. This may reflect differences in maturity, variety, and growing conditions. Freezer burn of some samples, especially spinach, was a factor in the high shear-force readings.

Of the fresh vegetables studied, total preparation time, including cooking, for 1 pound of vegetables ranged from 22 minutes for asparagus to 80 minutes for beets. Yields of fresh vegetables ranged from 38 percent for lima beans and green peas to 94 percent for green beans. As might be expected from the nature of the discarded portions, these values were lower than the corresponding values for frozen vegetables. Mean values for number of servings (usually ½ cup each) per purchase unit were highest for green beans, 6.5, and lowest for corn, about 1.

Ascorbic acid content of the uncooked fresh vegetables was lowest for green beans, 17 mg. per 100 g., and highest for brussels sprouts, 115 mg. per 100 g. Mean retention in the cooked vegetables was from 65 to 78 percent of that present in the uncooked. Mean values for ratios of oxidized to reduced ascorbic acid were generally low, indicating good quality especially in uncooked broccoli, 0.09, brussels sprouts, 0.11, and green peas, 0.13. Mean values for color in the uncooked vegetables did not differ greatly from those obtained for the frozen vegetables. Shear-force values for the uncooked vegetables, except for broccoli, ranged from 119 to 280 percent of the values for the frozen vegetables. Fresh broccoli, which was pared before cooking, had shear values averaging only 50 percent of those for the frozen broccoli.

Total preparation time of the canned vegetables

ranged from about 4 minutes for Harvard beets to 28 minutes for sirup-pack sweetpotatoes heated in a double boiler. Yields of the cooked ready-to-eat canned food ranged from about 50 percent in drained green beans and spinach to 100 percent for Harvard beets and dry-pack sweetpotatoes.

Mean values for percentage of ascorbic acid in the liquids of canned vegetables were about equal to those for the solids. Of the canned vegetables tested, spinach, with a mean value of about 6 mg. per 100 g., was highest in carotene content. Heating of the vegetables for serving cause little apparent loss in ascorbic acid and carotene beyond that already lost in processing.

Canned vegetables lacked the green color of fresh or frozen products. This was noted visually, by color difference meter readings, and by chlorophyll tests which showed almost complete conversion of chlorophyll to pheophytin.

PURPOSE OF THE INVESTIGATION

The widespread use of convenience foods has created interest regarding the quality, yield, and time required for kitchen preparation of fresh, frozen, and canned vegetables. Of the convenience foods, canned products are probably still most widely used (*11*).[1] In recent years, however, other types of foods with "built-in" service have made rapid gains. The pack of frozen vegetables in 1959 exceeded 1.6 billion pounds as compared with 73 million pounds packed in 1938 (*13*).

A few studies have been made on the cost, availability, time required for preparation, and some quality aspects of several forms of certain foods with varying degrees of built-in service (*2*, *7*,[2] *9*, *10*, *14*, *15*). However, some of the work was carried out before frozen foods had become readily available. The quality of fresh, frozen, and canned vegetables might be expected to be influenced by the development of new varieties and by changes in processing, storage, and retailing methods. Therefore, conclusions reached in investigations carried out several years ago might not be valid today.

To help meet the need for more up-to-date information about food products available in retail markets, the present exploratory investigation was carried out on a large variety of foods purchased in different market forms. In one phase of the work, data were obtained on preparation-time requirements, yield in servings, and quality of product. Research was conducted in companion projects to determine the effect of convenience factors on retail food prices and for a few, commodities case studies were made to provide data concerning margins in the analyses of costs of specific services added during processing, wholesaling, and retailing. The study was made in cooperation with the Marketing Economics Division, Economics Research Service. This report presents the findings on quality, yield, and preparation time of fresh, frozen, and canned vegetables.

SCOPE OF THE WORK

Eleven vegetables in various forms widely available on the retail market were included in the study.

The major part of the work comprised a comprehensive investigation of six fresh, frozen, and canned green vegetables: Broccoli, brussels sprouts, green beans, lima beans, green peas, and spinach. The frozen vegetables in this group were studied more extensively than the other forms because of the scarcity of information on the quality of frozen vegetables.

A more limited study was made of fresh, frozen, and canned asparagus, corn, and sweetpotatoes, and fresh and canned beets and carrots.

Preparation time and yield were determined on all the vegetables studied. Preparation included household handling prior to cooking as well as cooking time. On the six vegetables that were studied most extensively, ascorbic acid determinations and color difference meter and shear force readings were made, on both the uncooked and the cooked or heated samples. Dehydroascorbic acid plus diketogulonic acid was determined on the uncooked fresh and frozen vegetables and on both the unheated and heated canned vegetables. In addition, chlorophyll was determined on the uncooked and cooked, fresh and frozen vegetables, and carotene on the canned.

In the study on frozen vegetables, 67 or more lots of each of the six green vegetables were used, of which 64 samples were collected from the Washington area. Selected brands, four of brussels sprouts and three of each of the other vegetables, were purchased in each of the four seasons of the year from two or three stores under different managements and having high volume of sales in the locality. For each vegetable there was a total of four brand-store combinations. Four samples, one for each brand-store combination of a single vegetable, were studied per day. Each combination was replicated four times each season for four consecutive seasons beginning with the fall season.

The design of the stores and brands of frozen vegetables used in this bulletin was as follows:

[1] Italic numbers in parentheses refer to Literature Cited, p. 17.

[2] Out of print; available in libraries in most large cities.

Vegetable	Brands purchased in—		
	Store 1	Store 2	Store 3
Peas, green beans, lima beans	A B	A C	
Spinach, broccoli spears		A C	A D
Brussels sprouts	B	C	A D

In addition, two replicate determinations were made on a sample of each of the six frozen green vegetables obtained from each of four other metropolitan areas representing different regions of the country: New Orleans, La., Oakland, Calif., Milwaukee, Wis., and Philadelphia, Pa.

Fresh vegetables were obtained at the height of their seasons from a Washington, D.C., market. Quality evaluations were replicated eight times with vegetables purchased on different days.

Canned vegetables were obtained from three stores in the Washington area. Four brands each of green beans, lima beans, green peas, and spinach were purchased. A total of eight replications was made on each of these vegetables. The investigation of canned brussels sprouts was limited to one brand from one store, since no other brand or source of supply was readily available. Canned broccoli was not included in the study, as it could not be found in the area.

EXPERIMENTAL PROCEDURES

Purchase and Storage of Vegetables

Frozen vegetables from retail markets in the Washington area were obtained within a week of their intended use. They were transported to the laboratory in insulated shopping bags. Frozen vegetables from other areas were packed in dry ice and shipped to the laboratory in foam-plastic packing cases. All frozen vegetables were stored at −8° to −12° F.

Fresh vegetables were purchased the day before testing and stored in a walk-in refrigerator at 42° F.

Canned vegetables were stored at 73° F.

Preparation of Samples

Preparation Time.—The time required for each step in the preparation of the vegetables was recorded in one or both of two categories: Worker's time and total preparation time.

The worker's time was the time required by the worker for activities such as washing, paring, trimming, and cutting, and the time for water to come to a boil.

For quality determinations, duplicate cooking lots of the vegetables were prepared, one for the determination of chlorophyll, ascorbic acid, and carotene, and objective measurements of texture, and the other for measurement of reflected color.

Evaluations made on unheated samples required approximately 1 pound of fresh vegetable, three family-sized packages of frozen, or three No. 2 cans of vegetables.

Additional samples were used for cooking. A cooking lot of fresh vegetable consisted of 1 pound (454 grams) of edible portion. For a cooking lot of the frozen and canned vegetables studied most extensively, two packages or cans were used; for the others, one package or can.

Cooking Methods.—For cooking fresh vegetables and all frozen vegetables except sweetpotatoes, a predetermined amount of water was brought to the boiling temperature (as determined by thermocouple) in a covered 4-quart saucepan. The weighed vegetable was added and cooked until tender. With the exception of corn on the cob, the frozen vegetables were cooked without preliminary thawing.

Canned vegetables except sweetpotatoes were drained; the liquid was boiled in an uncovered pan until reduced to half its original volume, and the vegetable was added and heated for 1½ or 2 minutes, depending on the kind of vegetable.

Canned sweetpotatoes were heated in the top of a double boiler over boiling water, and frozen sweetpotatoes in an oven as directed on the package.

Quality Evaluation

Yield.—For frozen and canned vegetables yield data included the net weight as given on the container.

All foods were weighed in grams and weights were converted to ounces.

For the frozen vegetables, package contents were weighed and weight and volume of the drained vegetables were determined.

For fresh vegetables yield data included weight and description of inedible portions trimmed from the vegetable before washing, weight of raw trimmed vegetable after washing, and weight of the cooked product drained for 1 minute to separate liquids and solids.

For the canned vegetables, weight and volume of the total contents of the can were determined and also the weight and volume of the drained

solids and liquid, both before and after heating.

In addition, weights of ½-cup portions of cooked fresh, frozen, and canned vegetables were determined. The number of servings per purchase unit was calculated on the basis of equal-weight servings in different market forms of the same vegetable. If the weights of specified individual servings (usually ½ cup of drained vegetable) were not the same for all forms of the vegetable, the weight of the form with the greatest number of samples was selected for use in calculations. This figure was divided into the weight of the total cooked, drained food to determine the number of servings per purchase unit. Where ½-cup servings of frozen, fresh, and canned vegetables were unequal in weight, the calculated volume of equal weight servings were reported.

Reduced Ascorbic Acid.—Reduced ascorbic acid was determined by the indophenol procedure of Bessey and King (*1*). One-hundred gram portions of the vegetables were blended for 2 minutes in a Waring Blendor with 300 ml. of metaphosphoric acid and the resulting slurries diluted to 1,000 ml. with metaphosphoric acid. Five-percent acid was used for the raw fresh vegetables and 1 percent for the others. Fresh broccoli was cut into thin slices, under 5-percent metaphosphoric acid, before blending. This was necessary in order to inactivate the enzymes present.

Dehydroascorbic Acid Plus Diketogulonic Acid.—Determination of these products was made by reaction with 2,4-dinitrophenylhydrazine; the method used was a modification of the procedure described by Roe and coworkers (*17*). To 20 ml. of the extract were added 2 g. of thiourea and 10 ml. of 10-percent metaphosphoric acid and the solution was diluted to volume with 5-percent metaphosphoric acid. For the preparation of standard solutions, 50 ml. of 1 mg. per ml. ascorbic acid solution was oxidized with bromine, and the excess bromine removed by aeration. To 5 ml. of this solution was added 2.5 g. of thiourea and the mixture diluted to 250 ml. with 5-percent metaphosphoric acid. Then secondary dilutions were made with an aqueous solution containing 1-percent thiourea and 5-percent metaphosphoric acid for the preparation of solutions of 1, 3, and 5 μmg. per millileter of ascorbic acid equivalents, respectively. The remainder of the determination was carried out as described by Roe.

Carotene.—Carotene was determined according to the procedure of Wiseman, Irvin, and Moore (*21*). With broccoli and spinach, which are difficult to sample because of lack of uniformity, the following modification was used: One-hundred gram samples were blended with 100 g. of 95-percent ethanol for 2 minutes. Forty grams of the resulting slurry was then blended with 275 ml. of foaming solution and the procedure was continued as described by Wiseman.

Chlorophyll.—Chlorophyll was determined by the procedure of Mackinney and Weast (*12*) as modified by Sweeney and Martin (*19*). Specific absorption coefficients for changes in absorption upon conversion of chlorophyll to pheophytin were developed for 87-percent acetone extracts of each of the vegetables at 535, 642.5, and 660 mμ. In addition, specific absorption coefficients were developed for the absorption of chlorophyll and pheophytin at 556 mμ. By use of these coefficients, the percentage retention of chlorophyll was calculated as described previously (*19*).

Reflected Color.—Gardner Automatic Color Difference Meter (*6*) readings were taken on samples of most vegetables, both before and after heating or cooking. Broccoli and brussels sprouts were finely chopped. Samples of the other vegetables required no special preparation for color measurements. Readings were taken, using the "L" scale in which L expresses visual lightness, a_L redness or greenness, and b_L yellowness or blueness. Five readings were taken; between readings the sample was turned through about 72°. The average of the five measurements was considered the color value of the sample. A medium green color standard, L 50.0, $-a_L$ 25.7, $+b_L$ 7.3 was used for the vegetables tested.

Shear Force.—Determinations of shear force were made with a Lee-Kramer Shear Press (*8*), using a standard cell. A 3,000-pound proving ring was used for all vegetables, except canned peas and canned lima beans which required a 1,000-pound ring. One-hundred-gram samples of the vegetables were placed in the cell with stalks and large pieces at right angles to the blades. With broccoli, only the stalks were tested. Determinations were made both before and after heating or cooking the vegetables.

RESULTS AND DISCUSSION

Frozen Vegetables

Preparation Time.—Preparation times for frozen vegetables are shown in table 1. Worker preparation time was lowest for sweetpotatoes, 1 minute, and highest for corn, about 6 minutes. The other vegetables did not differ greatly in worker preparation time.

Total preparation time was highest for corn on cob, about 100 minutes, because of the 90 minutes defrosting time required before cooking. Sweetpotatoes and green beans were next highest, about 34 and 22 minutes, respectively. The other vegetables investigated did not differ greatly in total preparation time, about 12 to 18 minutes.

Table 1.—Frozen vegetables: *Preparation time required for family-sized units* [1]

Vegetable	Weight of market unit	Preparation time		Samples
		Worker	Total	
	Ounces	*Minutes*	*Minutes*	*Number*
Asparagus, spears	10	4¾	12½	4
Beans, green, cut	9	6	21¾	136
Beans, lima (Fordhook)	10	5½	17½	136
Broccoli spears	10	4¾	17¼	134
Brussels sprouts	10	5	18¼	136
Corn:				
On cob	(2)	6½	99½	4
Whole kernel	10	6½	12½	2
Peas, green	10	5	15	136
Spinach, leaf	10	5	13½	134
Sweetpotatoes, sliced	14	1	33½	2

[1] All vegetables except sweetpotatoes purchased in cardboard containers with waxed paper wrappings. Sweetpotatoes were in foil-lined cardboard containers.
[2] Two ears.

Yield.—In table 2 are given data on mean values and ranges for the net weight of the frozen vegetables as purchased, and after cooking. Also given are weight of serving, approximate size of serving, number of servings per market unit, and amount to buy for six servings.

The range in weight of vegetables per market unit as purchased was not great in most cases. Widest ranges were found in green beans, broccoli, brussels sprouts, and spinach. The ranges in net weight were small for frozen lima beans and green peas for 136 packages of each tested. Very small ranges were found in asparagus, sweetpotatoes, and whole kernel corn; however, only a limited number of samples of these vegetables were tested.

Lowest percentage yields of cooked drained food were obtained on spinach. The mean value was 77 with a range of 54 to 94 percent. Vegetables having the highest percentage yield were lima beans, corn, and sweetpotatoes, 97 to more than 100 percent. In general, the results obtained were similar to those reported by Dawson and associates (*3*) from institutional packs, and by Pecot and Watt (*16*) for data compiled from various sources and by Schlosser and others (*18*).

Ascorbic Acid.—Reduced ascorbic acid and dehydroascorbic acid are important because of their biological activity as vitamin C. Amounts of dehydroascorbic acid and diketogulonic acid, both of which are formed by the oxidation of reduced ascorbic acid, are expected to be small in the freshly harvested vegetables. In work carried out by the Western Utilization laboratories (*4*) it was found that in a frozen vegetable properly blanched and stored at 0° F. or lower, the ratio of oxidized to reduced ascorbic acid should be very low. Above 0° F., reduced ascorbic acid oxidizes to dehydroascorbic acid and diketogulonic acid, increasing the ratio. The amount of increase indicates the extent of storage above 0° F. A low ratio of oxidized to reduced ascorbic acid is therefore a measure of quality maintenance in fresh and frozen vegetables.

Some conversion of reduced to oxidized ascorbic acid would be expected to occur in canned vegetables because of the application of heat during the canning process. The amount of these oxidation products is therefore not so indicative of expected quality in canned vegetables as in the frozen or fresh forms.

Dehydroascorbic acid is biologically available as vitamin C and diketogulonic acid is not. Although the two compounds were not differentiated in this work, a portion of the ascorbic acid oxidation products might be expected to be in the form of the biologically available dehydroascorbic acid.

In table 3 are shown mean values and ranges for reduced ascorbic acid and ratios of dehydroascorbic acid plus diketogulonic acid to reduced ascorbic acid in the six frozen vegetables from the Washington area and studied most extensively. Shown for comparison, table 4, are results on samples obtained from other metropolitan areas. In general, these values were within the range for products bought in Washington, D.C. The data on samples from areas other than Washington are based on evaluations made on single cartons of family-sized packages of frozen vegetables.

Ascorbic acid content varied over a considerable range in all vegetables investigated. However, coefficients of variation were relatively low, 12 to 13, except for green beans, 33, and spinach 37, indicating that in general ascorbic acid values did not differ greatly from the mean values.

Values for ratios of dehydroascorbic acid plus diketogulonic acid were somewhat more variable than were the corresponding values for reduced ascorbic acid. This is indicated by the larger coefficients of variation, 29 to 50, for the vegetables, excluding spinach. In spinach, a few very high values were responsible for the high coefficient of variation for this vegetable.

Ascorbic acid retention in the cooked vegetables was also highly variable. The vegetables were cooked to optimum texture in each case. As with the uncooked vegetables, highest coefficients of variation were obtained for spinach and green beans.

In general, mean values for ascorbic acid content of samples from the Washington, D.C., area were similar to values for the other four areas from which samples were obtained. However, for samples of green peas and green beans received from New Orleans, both reduced ascorbic acid content and ascorbic acid oxidation ratios indicated poor quality.

TABLE 2.—FROZEN VEGETABLES: *Yield of cooked food as served* [1]

Vegetable	Labeled weight of market unit	Weight of food per market unit [2]		Yield of cooked drained food		Servings, cooked drained food			Amounts as purchased needed for 6 servings	Samples
		Mean	Range	Mean	Range	Weight per serving	Approximate size	Servings per market unit as purchased		
	Ounces	*Ounces*	*Ounces*	*Percent*	*Percent*	*Ounces*		*Number*	*Ounces*	*Number*
Asparagus spears	10	10. 1	10. 0–10. 1	93	93– 94	2. 1	6 small spears	4. 5	14	2
Beans, green cut	9	9. 3	8. 0–10. 4	91	76–104	2. 3	0.5 cup	3. 7	15	136
Beans, lima (Fordhook)	10	10. 2	9. 6–10. 9	100	93–108	2. 9	.5 cup	3. 5	17	136
Broccoli, spears	10	10. 3	9. 3–11. 4	85	74– 95	3. 3	3 small stalks	2. 7	23	134
Brussels sprouts	10	10. 2	9. 8–11. 9	96	87–107	2. 7	.5 cup	3. 6	17	136
Corn:										
On cob	----------	15. 3	14. 7–16. 2	101	95–107	6. 1	1 ear	2. 5	36	4
Whole kernel	10	9. 9	9. 8–10. 0	97	96– 99	2. 9	.5 cup	3. 3	18	2
Peas, green	10	10. 1	9. 5–10. 9	85	77– 92	2. 8	.5 cup	3. 1	20	136
Spinach, leaf	10	10. 3	9. 4–12. 0	77	54– 94	3. 4	.5 cup	2. 3	26	134
Sweetpotatoes, candied	14	13. 8	13. 7–13. 9	100	99–101	4. 4	.5 cup	3. 1	26	2

[1] All vegetables except sweetpotatoes purchased in cardboard containers with waxed paper wrappings. Sweetpotatoes were in foil-lined cardboard containers.

[2] All foods were weighed in grams and converted to ounces.

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TABLE 3.—FROZEN GREEN VEGETABLES: *Quality characteristics of samples from Washington, D.C., retail markets* [1]

Vegetable	Ascorbic acid [2]			$\frac{DH+DK}{AsA}$ [3]			Chlorophyll conversion (pheophytin)			Color difference meter [4]			Shear value		
	Mean	Range	C.V.[5]	Mean	Range	C.V.[5]	Mean	Range	C.V.[5]	Mean	Range	C.V.[5]	Mean	Range	C.V.[5]
	Uncooked														
	Mg./100 g.	*Mg./100 g.*	*Percent*			*Percent*	*Percent*	*Percent*	*Percent*	a_L/b_L *values*	a_L/b_L *values*	*Percent*	*Lb. force*	*Lb. force*	*Percent*
Beans, green	9	3– 20	33	0. 54	0. 14–1. 71	50	23	0–53	39	0. 92	0. 48–1. 05	10	721	512– 890	12
Beans, lima (Fordhook)	17	10– 24	12	. 35	. 12– . 93	30	28	0–48	26	. 59	. 42– . 70	8	390	280– 490	10
Broccoli spears	68	38– 93	13	. 16	. 06– . 40	29	19	0–38	23	. 83	. 67–1. 01	7	1, 590	680–2, 230	19
Brussels sprouts	79	50–122	13	. 20	. 11– . 55	30	31	0–48	19	. 42	. 24– . 67	24	531	280– 855	17
Peas, green	18	8– 24	13	. 30	. 11–1. 01	37	10	0–23	49	. 94	. 88–1. 04	2	440	340– 542	9
Spinach, leaf	34	6– 65	37	. 36	. 06–4. 22	142	10	0–29	50	1. 10	. 92–1. 26	6	586	172–1, 170	31
	Cooked														
Beans, green	6	2– 12	28	------	----------	------	73	59–90	7	0. 49	0. 31– . 69	11	91	8– 172	22
Beans, lima (Fordhook)	12	4– 17	11	------	----------	------	60	32–83	14	. 41	. 26– . 52	16	170	65– 290	25
Broccoli spears	48	28– 66	16	------	----------	------	55	40–66	10	. 59	. 45– . 79	10	308	123– 582	34
Brussels sprouts	59	33– 90	18	------	----------	------	79	69–88	5	. 22	. 13– . 35	18	103	8– 247	40
Peas, green	12	4– 19	17	------	----------	------	32	16–48	20	. 77	. 63– . 91	5	182	27– 340	33
Spinach, leaf	20	4– 43	34	------	----------	------	23	2–42	25	1. 00	. 75–1. 18	8	180	38– 381	29

[1] Mean values represent 64 samples.
[2] Reduced ascorbic acid.
[3] Ratio of dehydroascorbic acid plus diketogulonic acid to reduced ascorbic acid.
[4] Mean of 5 values on each sample.
[5] Coefficient of variation.

TABLE 4.—FROZEN GREEN VEGETABLES: *Quality characteristics of samples from areas other than Washington, D.C.*[1]

Vegetable	Area	Date tested in 1959	Ascorbic acid [2]	$\frac{DH+DK}{AsA}$ [3]	Chlorophyll conversion (pheophytin)	Color difference meter [4]	Shear values
	Uncooked						
			Mg./100 g.		*Percent*	a_L/b_L *values*	*Lb. force*
Beans, green	Philadelphia, Pa	June 2	11	0.54	23	0.88	716
	New Orleans, La	Aug. 4	3	1.97	68	.54	873
	Milwaukee, Wis	Oct. 5	12	.53	12	1.00	630
	Oakland, Calif	Nov. 16	11	.99	23	.98	500
Beans, lima (Fordhook)	Philadelphia, Pa	June 2	14	.73	42	.60	371
	New Orleans, La	Aug. 3	11	.77	50	.49	340
	Milwaukee, Wis	Oct. 6	17	.37	23	.62	390
	Oakland, Calif	Nov. 17	17	1.13	20	.56	430
Broccoli spears	Philadelphia, Pa	June 3	59	.10	----	----	----
	New Orleans, La	Aug. 4	38	.71	34	.79	1615
	Milwaukee, Wis	Oct. 6	66	.10	18	.79	1910
	Oakland, Calif	Nov. 17	50	.15	26	.77	1530
Brussels sprouts	Philadelphia, Pa	June 1	87	.02	57	.37	350
	New Orleans, La	Aug. 4	92	.24	37	.46	381
	Milwaukee, Wis	Oct. 6	79	.14	33	.48	328
	Oakland, Calif	Nov. 16	79	.04	32	.42	610
Peas, green	Philadelphia, Pa	June 1	18	.32	28	.96	440
	New Orleans, La	Aug. 3	9	.82	30	.84	542
	Milwaukee, Wis	Oct. 5	20	.12	10	.91	470
	Oakland, Calif	Nov. 16	20	.18	9	.94	480
Spinach, leaf	Philadelphia, Pa	June 3	24	.50	----	----	----
	New Orleans, La	Aug. 4	24	.19	27	1.06	716
	Milwaukee, Wis	Oct. 5	52	.20	6	1.16	630
	Oakland, Calif	Nov. 17	31	.19	4	1.10	760
	Cooked						
Beans, green	Philadelphia, Pa	June 2	7	----	73	0.44	84
	New Orleans, La	Aug. 4	3	----	88	.40	162
	Milwaukee, Wis	Oct. 5	8	----	68	.53	55
	Oakland, Calif	Nov. 16	4	----	76	.49	84
Beans, lima (Fordhook)	Philadelphia, Pa	June 2	12	----	82	.34	182
	New Orleans, La	Aug. 3	8	----	73	.41	123
	Milwaukee, Wis	Oct. 6	12	----	50	.47	162
	Oakland, Calif	Nov. 17	14	----	53	.32	202
Broccoli spears	Philadelphia, Pa	June 3	39	----	----	----	----
	New Orleans, La	Aug. 4	34	----	66	.58	328
	Milwaukee, Wis	Oct. 6	52	----	62	.61	371
	Oakland, Calif	Nov. 17	42	----	54	.46	280
Brussels sprouts	Philadelphia, Pa	June 1	83	----	84	.17	84
	New Orleans, La	Aug. 4	72	----	86	.17	143
	Milwaukee, Wis	Oct. 6	50	----	78	.23	74
	Oakland, Calif	Nov. 16	64	----	82	.17	94
Peas, green	Philadelphia, Pa	June 1	15	----	52	.75	152
	New Orleans, La	Aug. 3	4	----	50	.76	260
	Milwaukee, Wis	Oct. 5	12	----	23	.69	247
	Oakland, Calif	Nov. 16	13	----	35	.78	230
Spinach, leaf	Philadelphia, Pa	June 3	9	----	----	----	----
	New Orleans, La	Aug. 4	11	----	34	.92	172
	Milwaukee, Wis	Oct. 5	27	----	38	1.04	----
	Oakland, Calif	Nov. 17	27	----	25	.96	143

[1] Each value represents mean of 2 replications.
[2] Reduced ascorbic acid.
[3] Ratio of dehydroascorbic acid plus diketogulonic acid to reduced ascorbic acid.
[4] Mean of 5 values on each of 2 replications.

In table 5 relationship of brand to ascorbic acid is shown. Differences significant at the 5-percent level were found only for green beans, lima beans, and brussels sprouts.

Color.—The percentage of chlorophyll which remains unconverted to pheophytin is of particular importance as a measure of quality. If frozen vegetables have been properly blanched before freezing and are stored at temperatures of 0° F. or below, chlorophyll retention should remain at a high level. At temperatures above 0° F. there is a progressive conversion of chlorophyll to pheophytin (*4*). A low percentage of chlorophyll conversion is directly related to the retention of desirable color.

There was considerable variation in percentage conversion of chlorophyll in all vegetables investigated, table 4. The mean value for spinach and for green peas was only 10 percent as compared with 31 percent for brussels sprouts and 23 percent for green beans. However, chlorophyll is known to be more stable in spinach and green peas than in green beans and brussels sprouts. Recent work on the stability of chlorophyll in green vegetables (*20*) would indicate that a value of 10 percent conversion in spinach or green peas would represent approximately the same amount of exposure to temperature above 0° F. as would a value of 31 percent for brussels sprouts. It is likely, therefore, that these differences in chlorophyll conversion percentages reflect, to a considerable extent, differences in the vegetables rather than differences in storage conditions.

In the cooked vegetables, chlorophyll conversion was also lowest in green peas and spinach, while brussels sprouts and green beans showed the highest values for percentage conversion.

Of the samples received from other areas, those from New Orleans were generally highest in percentage of chlorophyll conversion. This was in agreement with results of ascorbic acid values which tended also to indicate poor quality of vegetables obtained from that area.

In general, there were few significant differences in chlorophyll conversion between brands. For green beans, chlorophyll conversion in Brand C, Store 2 was significantly higher than in Brand A, Store 2.

In table 6 the relationships of season of purchase to chlorophyll stability are shown. The percentage conversion of chlorophyll to pheophytin in broccoli tested in the summer season was significantly higher than in that tested during the other three seasons. In brussels sprouts, percentage conversion of chlorophyll to pheophytin was significantly higher in summer than in winter or spring. Samples of brussels sprouts tested in fall were likewise significantly higher in chlorophyll conversion than were those tested in winter. In lima beans, chlorophyll conversion was significantly higher in summer than in winter. There were no other significant differences in chlorophyll stability that could be attributed to season. The relatively high values for chlorophyll conversion for samples tested in the summer season may reflect difficulty in keeping the storage temperature below 0° F. during extremely warm weather. The longer storage period between packing and sale for broccoli and brussels sprouts may also be a factor in the poor chlorophyll retention for samples of these vegetables tested in the summer season.

TABLE 5.—FROZEN GREEN VEGETABLES: *Ascorbic acid and chlorophyll conversion in samples of different brands from Washington, D.C., retail markets* [1]

Vegetable	Brand	Store	Ascorbic acid	Chlorophyll conversion (pheophytin)
			Mg./100 g.	*Percent*
Beans, green	A	1	7	25
	A	2	11	15
	B	1	11	24
	C	2	7	30
Test difference [2]			4	12
Beans, lima (Fordhook)	A	1	16	27
	A	2	16	28
	B	1	19	25
	C	2	17	29
Test difference [2]			3	10
Broccoli spears	A	2	67	18
	A	3	66	19
	C	2	68	20
	D	3	70	18
Test difference [2]			12	6
Brussels sprouts	A	3	75	35
	B	1	70	30
	C	2	75	30
	D	3	96	29
Test difference [2]			8	8
Peas, green	A	1	16	12
	A	2	19	9
	B	1	19	8
	C	2	17	11
Test difference [2]			4	5
Spinach, leaf	A	2	28	10
	A	3	33	8
	C	2	35	10
	D	3	41	12
Test difference [2]			17	7

[1] Each value is mean of 16 samples.

[2] The difference between 2 means is significant at the 5-percent level when it equals or exceeds the test difference (*5*).

Table 6.—Frozen green vegetables: *Chlorophyll conversion in samples purchased in four seasons of the year from Washington, D.C., retail markets* [1]

Vegetable	Winter	Spring	Summer	Fall	Test difference [2]
	Percent	*Percent*	*Percent*	*Percent*	
Beans, green	19	20	30	25	12
Beans, lima (Fordhook)	21	30	32	28	10
Broccoli spears	16	18	25	14	6
Brussels sprouts	24	29	38	33	8
Peas, green	9	9	12	11	5
Spinach, leaf	8	12	9	11	7

[1] Values are mean of 16 samples of vegetables as received.
[2] The difference between 2 means is significant at the 5-percent level when it equals or exceeds the test difference.

In the uncooked vegetables, highest a_L/b_L values were obtained for spinach, green peas, and green beans, table 3. The high values agree with results of chorophyll determinations which showed the lowest percentage conversion of chlorophyll to pheophytin in these vegetables. Lima beans and brussels sprouts, which were highest in percentage conversion of chlorophyll, were lowest in a_L/b_L readings as would be expected.

In the cooked vegetables, greatest chlorophyll losses occurred in those vegetables that had shown the greatest chlorophyll instability before cooking. This is shown by the high mean values for chlorophyll conversion in cooked brussels sprouts and conversely by the comparatively low values in cooked spinach and green peas. Color difference meter a_L/b_L values generally agreed with chlorophyll conversion percentages.

Texture (shear force).—There were wide texture variations in all uncooked frozen vegetables investigated, table 3. This was especially true of spinach, which had a range in shear value of 172 to 1,170 pounds, broccoli, 680 to 2,230, and brussels sprouts, 280 to 855. The high shear readings obtained on some samples of spinach probably reflect freezer burn. In broccoli and brussels sprouts. differences in diameter of the stem and in the thickness of the fibrovascular or outer portion of the stem could cause large differences in shear-force readings. Texture differences in all vegetables could also reflect differences in growing environment as well as maturity and variety differences.

There were wide texture ranges in the cooked vegetables even though they were, in each case, cooked as nearly as possible to the tender stage. Spinach and broccoli, which were most variable as received, also had the widest range in mean texture scores when cooked, probably because of the uneveness in texture and structure of these vegetables.

Fresh Vegetables

Preparation Time.—Preparation times for fresh vegetables are given in table 7. Worker preparation time for 1 pound as purchased was lowest for asparagus, about 6 minutes, and highest for corn on the cob, 23 minutes, and corn cut off the cob, 31 minutes. Worker preparation time for the other vegetables ranged from about 10 minutes to over 18 minutes.

Total preparation time was highest for beets, about 80 minutes, and lowest for asparagus, about 22 minutes. Other vegetables ranged from approximately 25 minutes to almost 58 minutes in total preparation time.

Yield.—In table 8 data are given on the yield of fresh vegetables purchased from retail markets in the Washington, D.C., area.

Table 7.—Fresh vegetables: *Preparation time required for 1 pound purchased in bulk*

Vegetable	Method of preparation	Preparation time		Samples
		Worker	Total	
		Minutes	*Minutes*	*Number*
Asparagus	Spears	6¼	21½	4
Beans, green	Cut	18½	34¼	4
Beans, lima	Shelled	15	41¼	4
Beets, with tops	Sliced	14½	79½	3
Broccoli	Spears	16½	32¼	4
Brussels sprouts	Whole	9¾	26	4
Carrots	Sliced	12¼	36¼	3
Corn [1]	Husk and silk removed.	23¼	38¼	2
	Cut off cob	31¼	46¼	2
Peas, green	Shelled	11¾	26	4
Spinach	Leaf	18½	24¾	7
Sweetpotatoes	Whole	11½	57¾	4

[1] Total of six ears.

The discarded portions of the fresh vegetables would cause the yields of this vegetable form to differ from the corresponding values for the frozen vegetables. Lowest percentage yields of cooked drained food were obtained on lima beans and green peas, 37 and 38 percent. Asparagus, beets,

Table 8.—Fresh vegetables: *Yield of cooked food as served and parts discarded from 1 pound purchased in bulk*

Vegetable	Method of preparation	Parts discarded		Yield of ready to cook food [1 2]	Yield of cooked drained food [1]		Servings, cooked drained food [3]			Amount purchased in bulk for 6 servings	Samples
		Weight [1]	Description		Based on food as purchased	Range	Weight per serving	Approximate size	Servings per pound as purchased		
		Percent		*Percent*	*Percent*	*Percent*	*Ounces*		*Number*	*Ounces*	*Number*
Asparagus	Spears	54	Tough ends of stalks	47	47	41– 52	2. 1	2.3 large spears.	3. 6	27	4
Beans, green	Cut	9	Ends and trimmings	93	94	84–101	2. 3	.5 cup	6. 5	15	16
Beans, lima	Shelled	64	Pods and imperfect beans.	38	37	29– 46	2. 9	.5 cup	2. 0	47	16
Beets, with tops	Sliced	39	Tops, stem-ends, and peelings.	68	54	52– 58	3. 2	.5 cup	2. 7	36	3
Broccoli	Spears	30	Tough stalk ends, parings and leaves.	69	69	62– 81	3. 3	2 medium stalks.	3. 4	29	16
Brussels sprouts	Whole	28	Outer leaves and trimmings.	76	79	71– 88	2. 7	.5 cup, 3.7 large sprouts.	4. 7	20	16
Carrots	Sliced crosswise.	21	Ends and scrapings	79	74	72– 76	2. 8	.5 cup	4. 2	23	3
Corn [4]	Husks and silk removed.	30	Husks, silks, and trimmings.	70	74	63– 85	6. 1	1 ear	1. 0	49	6
	Cut off cob	57	Husks, silks, trimmings, and cob.	--------	44	33– 52	2. 9	.6 cup	1. 1	40	6
Peas, green	Shelled	61	Pods and imperfect peas.	40	38	31– 44	2. 8	.5 cup	2. 1	44	16
Spinach	Leaf	36	Stem ends and spoiled leaves.	79	60	41– 88	3. 4	.5 cup	2. 8	34	16
Sweetpotatoes	Whole	15	Parings and trimmings	--------	84	82– 86	4. 4	.5 cup	3. 0	31	4

[1] Percent is based on weight of food as purchased.
[2] Yield of discarded parts and ready to cook food is not always equal to 100 percent because vegetables were washed before trimming.
[3] All foods were weighed in grams and converted to ounces.
[4] Unit of purchase of corn was 1 ear with a mean weight of 8.2 ounces per ear, based on 6 samples.

and corn cut from the cob also tended to be low in percentage yield, from 44 to 54 percent. The highest yield was obtained on green beans, 94 percent. Yield of other vegetables ranged from 60 to 84 percent.

The mean values for number of servings per purchase unit of cooked drained food was highest for green beans, 6.5, and lowest for corn, 1.0 and 1.1. Brussels sprouts. 4.7, and carrots, 4.2, were next highest with the other vegetables being similar in this respect.

Ascorbic Acid.—Results of ascorbic acid determinations are shown in table 9. Spinach, which was highly variable in ascorbic acid when frozen, also showed wide ranges in content of this vitamin when in the fresh condition, 4 to 40 mg. per 100 g. The ascorbic acid range in the other fresh vegetables investigated was not great.

Widest ranges in ratios of oxidized to reduced ascorbic acid were found in spinach, green beans, and lima beans. The mean values, however, were in most cases somewhat lower than those for the frozen vegetables. The higher reduced ascorbic acid values for the fresh vegetables would tend to make the oxidation ratios lower than the corresponding values for the frozen vegetables.

In general, the results obtained on the cooked fresh vegetables did not differ greatly from those for the frozen vegetables. The ascorbic acid content of the cooked fresh vegetables was usually slightly higher than that of the frozen. In general, retention was about 80 percent of that present in the uncooked fresh vegetable. Spinach, which was most variable in ascorbic acid in the raw state, also had the greatest variation when cooked. There were wide ranges in ratios of oxidized to reduced ascorbic acid in cooked samples of fresh vegetables, especially in lima beans.

Color.—The mean values for percentage of chlorophyll conversion in the raw green vegetables ranged from 0.1 percent in green beans to 19 percent in lima beans. Greatest chlorophyll instability was found in lima beans in which the range was from 6 to 47 percent and the mean value 19 percent. Color difference meter a_L/b_L values ranged from 0.38 in brussels sprouts to 0.86 in spinach.

Chlorophyll conversion values, except those of green peas, were lower in the fresh than in the frozen vegetables. Despite the fact that the frozen vegetables were higher in percentage of chlorophyll conversion than were the fresh, they had a brighter green color, as shown by the higher color difference meter values for the frozen vegetables as compared with the fresh. It appears that the blanching of green vegetables prior to freezing causes an apparent increase in green color, due perhaps to increased transparency of plant tissue, or expulsion of air from the cells.

Of the fresh vegetables, spinach and green peas retained their color best during cooking, as shown by chlorophyll conversion and color difference meter values. These results are similar to those obtained on cooked frozen vegetables which also showed best color retention in these two vegetables.

Chlorophyll conversion values were somewhat lower and color difference meter a_L/b_L values higher for the cooked frozen vegetables than for the fresh, except for spinach. However, in most cases, the differences were not great.

Texture.—Shear-force values for the uncooked fresh vegetables were generally higher than those for the frozen. This would be expected because of the partial cooking of the frozen vegetables during blanching. Broccoli was an exception. Paring of the fresh broccoli stems before cooking probably accounts for the lower shear readings obtained on the fresh vegetable.

For the cooked fresh and frozen vegetables mean shear-force values, except for broccoli and spinach, were generally similar. Fresh broccoli and spinach had readings considerably lower than those of their frozen counterparts.

Canned Vegetables

Preparation Time.—Preparation times for canned vegetables are given in table 10. Worker preparation time was quite low in most cases, ranging from ½ to 1½ minutes, except for sirup-pack and dry-pack sweetpotatoes which required about 4 and 5 minutes worker preparation time, respectively.

Total preparation time varied from 4½ minutes for Harvard beets to 28 minutes for sirup-pack sweetpotatoes. For other vegetables the range was from about 7 to 13 minutes.

Yield.—Data on the yield of canned vegetables purchased from retail markets in the Washington, D.C., area are given in table 11.

The range in weight of vegetables per market unit as purchased was generally quite small as would be expected in standardized containers and packs. It was somewhat greater for canned vegetables after heating, particularly green beans, sliced carrots, peas, and spinach.

Highest percentage yields of cooked food, 100 percent, were obtained on Harvard beets and dry-pack sweetpotatoes, which were served without draining. Lowest yields were found on drained green beans and spinach, about 50 percent. Mean yields for other vegetables ranged from 58 to 68 percent.

The mean value for number of servings per purchase unit of cooked vegetable was highest for Harvard beets, 5.4, and lowest for brussels sprouts, 2.0, and spinach, 2.3. Asparagus and dry-pack sweetpotatoes were next highest, 4.4. The number

Table 9.—Fresh green vegetables: *Quality characteristics of samples from Washington, D.C., retail markets* [1]

Vegetable	Ascorbic acid		$\frac{DH+DK}{AsA}$		Chlorophyll conversion (pheophytin)		Color difference meter [2]		Shear value	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
	Raw									
	Mg./100 g.	*Mg./100 g.*			*Percent*	*Percent*	a_L/b_L *values*	a_L/b_L *values*	*Lb. force*	*Lb. force*
Beans, green	17	11– 22	0. 20	0. 06–0. 34	0. 1	0– 1	0. 66	0. 55–0. 74	979	813–1, 170
Beans, lima (Fordhook)	26	20– 35	. 23	. 06– . 99	19	6–47	. 45	. 37– . 49	979	770–1, 160
Broccoli spears	104	91–114	. 09	. 06– . 10	10	0–30	. 64	. 60– . 70	796	699- 915
Brussels sprouts	115	108–129	. 11	. 08– . 17	7	0–21	. 38	. 30– . 46	1, 488	320–1, 625
Peas, green	27	22– 35	. 13	. 04– . 19	16	0–24	. 62	. 58– . 65	685	590– 805
Spinach, leaf	26	4– 40	. 36	. 12–1. 06	8	0–18	. 86	. 75– . 96	696	430– 925
	Cooked									
Beans, green	13	10– 17	0. 30	0. 16–0. 40	82	81–84	0. 40	0. 27–0. 49	88	18– 132
Beans, lima (Fordhook)	18	12– 25	. 47	. 11–2. 20	88	84–96	. 23	. 14– . 34	184	152– 238
Broccoli spears	81	62– 98	. 13	. 10– . 20	67	60–79	. 50	. 39– . 55	172	74– 350
Brussels sprouts	89	73– 98	. 13	. 09– . 18	84	65–94	. 19	. 14– . 25	134	94– 192
Peas, green	20	16– 24	. 18	. 06– . 34	55	35–64	. 54	. 43– . 66	208	132– 320
Spinach, leaf	17	2– 35	. 21	. 09– . 33	23	8–19	1. 03	. 80–1. 18	117	55– 247

[1] Mean values represent 8 samples.
[2] Represents 5 replications on each sample.

of servings per market unit for the other vegetables ranged from 3.3 to 4.0.

Ascorbic Acid.—In the canned vegetables, ascorbic acid determinations were made on both solids and liquids, table 12. In calculating the vitamin content of the heated solids and liquids, corrections were made for losses in weight which occurred during the concentrating and heating process.

In general, the percentages of reduced and oxidized ascorbic acid in the drained liquids were about equal to amounts present in the solids.

In most cases, the mean ascorbic acid values of the heated solids were similar to or slightly lower than those of the unheated. The percentage of ascorbic acid present in the liquids was about the same as in the solids. This would indicate that when the liquid portion of canned vegetables is not used, as much as 50 percent of the ascorbic acid would be discarded. The ratios of oxidized to reduced ascorbic acid were high in the heated canned vegetables, especially in lima beans and green peas.

Carotene.—Of the canned vegetables tested, spinach with a mean of about 6 mg. per 100 g. was highest in carotene. Heating of the vegetable caused no apparent carotene loss.

Color.—Preliminary tests showed substantially complete conversion of chlorophyll to pheophytin in the canned green vegetables tested. Consequently, chlorophyll determinations were not routinely made.

Color difference meter a_L/b_L values were low, as would be expected. Lowest mean values were obtained for lima beans, 0.07, and green beans, 0.08. Spinach, with a mean of 0.20 and a range of 0.15 to 0.34, was highest.

Heating of the canned green vegetables appeared to cause no further loss in color. Mean a_L/b_L values and ranges in values for the heated vegetables were similar to those of the unheated samples.

Texture.—Mean shear values for all canned vegetables were low as would be expected when compared with values for fresh or frozen vegetables. Mean values for the unheated vegetables ranged from 68 pounds for green beans to 181 for lima beans. For the heated vegetables the range of means was from 68 for green beans to 155 for spinach.

TABLE 10.—CANNED VEGETABLES: *Preparation time required for family-sized units*

Vegetable	Market unit		Preparation time		Samples
	Container	Weight	Worker	Total	
		Ounces	*Minutes*	*Minutes*	*Number*
Asparagus, spears	No. 300 can	14. 5	½	7	4
Beans, green, cut	No. 303 can	15. 5 or 16. 0	½	12½	16
Beans, lima	No. 303 can	16. 0 or 17. 0	½	10½	16
Beets:					
Diced, plain	Glass jar	16. 0	¾	7¾	2
Diced, Harvard	Glass jar	16. 0	1¼	4½	2
Brussels sprouts	Buffet size can	8. 0	½	10	4
Carrots:					
Sliced	No. 303 can	16. 0	½	7½	4
Diced	Glass jar	16. 0	1¼	7¾	4
Corn, whole kernel	No. 303 can	16. 0	¾	7¾	2
Peas, green	No. 303 can	16. 0 or 17. 0	½	12½	16
Spinach, leaf	No. 303 can	15. 0	1½	13	16
Sweetpotatoes:					
Sirup pack	No. 3 squat can	23. 0	4½	28	2
Dry pack	No. 3 squat can	18. 0	5¼	20¼	2

TABLE 11.—CANNED VEGETABLES: *Yield of cooked food as served*

Vegetable	Market unit		Actual weight of food per market unit [1]		Yield of heated drained food		Servings, cooked drained food			Amount as purchased needed for 6 servings	Samples
	Container	Weight on label	Mean	Range	Mean	Range	Weight per serving	Approximate size	Servings per market unit as purchased		
		Ounces	*Ounces*	*Ounces*	*Percent*	*Percent*	*Ounces*		*Number*	*Ounces*	*Number*
Asparagus, spears	No. 303 can	14. 5	14. 8	14. 3–15. 4	63	59– 68	2. 1	4 medium spears	4. 4	20	4
Beans, green, cut	No. 303 can	15. 5 or 16. 0	16. 6	16. 3–17. 0	49	43– 53	2. 3	0.5 cup	3. 6	28	16
Beans, lima	No. 303 can	16. 0 or 17. 0	16. 9	16. 4–17. 2	60	57– 62	2. 9	. 5 cup	3. 5	29	16
Beets:											
Diced, plain	Glass jar	16. 0	16. 8	16. 7–16. 9	62	61– 63	3. 2	. 6 cup	3. 3	31	4
Diced, Harvard	Glass jar	16. 0	17. 2	17. 1–17. 3	[2] 100	99–101	3. 2	. 4 cup	5. 4	19	4
Brussels sprouts	Buffet size can	8. 0	8. 7	8. 5– 8. 9	62	60– 66	2. 7	. 4 cup, about 13 small sprouts.	2. 0	26	4
Carrots:											
Sliced	No. 303 can	16. 0	16. 6	16. 6–16. 7	63	57– 70	2. 8	. 5 cup	3. 8	27	4
Diced	Glass jar	16. 0	16. 4	15. 8–17. 1	68	66– 71	2. 8	. 5 cup	4. 0	25	4
Corn, whole kernel	No. 303 can	16. 0	17. 1	17. 0–17. 1	61	59– 63	2. 9	. 5 cup	3. 6	29	4
Peas, green	No. 303 can	16. 0 or 17. 0	16. 8	16. 6–17. 1	58	54– 63	2. 8	. 5 cup	3. 5	29	16
Spinach, leaf	No. 303 can	15. 0	15. 4	14. 4–15. 8	51	40– 60	3. 4	. 4 cup	2. 3	40	16
Sweetpotatoes:											
Sirup pack	No. 3 squat can	23. 0	25. 4	24. 4–26. 3	63	61– 66	4. 4	. 5 cup	3. 7	42	2
Dry pack	No. 3 squat can	18. 0	19. 4	18. 5–20. 3	100	95–105	4. 4	. 5 cup	4. 4	26	2

[1] All foods were weighed in grams and converted to ounces.
[2] Harvard beets were served without draining.

TABLE 12.—CANNED GREEN VEGETABLES: *Quality characteristics of samples from Washington, D.C., retail markets* [1]

Vegetable	Solids										Liquids			
	Ascorbic acid		$\frac{DH+DK}{AsA}$		Carotene		Color difference meter [2]		Shear value		Ascorbic acid		$\frac{DH+DK}{AsA}$	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
	Unheated													
	Mg./100 g.	*Mg./100 g.*			*Mmg./100 g.*	*Mmg./100 g.*	a_L/b_L *values*	a_L/b_L *values*	*Lb. force*	*Lb. force*	*Mg./100 g.*	*Mg./100 g.*		
Beans, green	4	2–6	0.59	0.33–0.71	352	267–453	0.08	0.01–0.14	68	56–76	4	2–6	0.23	0.04–0.61
Beans, lima	5	2–7	.91	.02–2.38	138	110–180	.07	.06–.10	181	168–191	7	4–11	.65	.16–1.08
Peas, green	7	3–12	.98	.29–2.50	361	227–427	.12	.10–.15	115	58–191	8	2–13	.64	.21–1.66
Spinach, leaf	19	6–33	.22	.11–.36	5,924	4,930–7,100	.20	.15–.34	130	61–222	19	6–36	.26	.14–.56
	Heated													
Beans, green	3	2–6	0.48	0.22–0.65	358	267–460	0.09	0.01–0.15	68	58–83	2	1–4	0.36	0.15–0.56
Beans, lima	3	2–5	1.62	1.02–4.05	119	89–174	.07	.06–.09	123	100–146	4	2–6	.83	.28–2.24
Peas, green	5	1–29	1.74	.64–6.08	328	239–382	.12	.08–.14	100	66–184	4	2–6	1.00	.46–1.86
Spinach, leaf	18	4–28	.36	.26–.68	6,090	4,837–6,905	.23	.18–.32	155	76–254	14	3–24	.36	.23–.50

[1] Values are mean of 8 samples.
[2] Mean of 5 values per sample.

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